Appendix C2. Large Woody Debris Surveys

CONTENTS

Figures

Tables

C2.1 OBJECTIVES AND METHODS

In the following description, there is a difference between an inventory and a sample. A sample is a type of survey where the crewmember only counts and measures LWD pieces within a certain percentage (i.e. 20% sample) of the stream length. An inventory is a survey in which all pieces are counted and measured for the entire anadromous stream length.

C2.1.1 Number of Streams Sampled and/or Inventoried

An in-channel and recruitment zone large woody debris (LWD) survey was conducted on 16 streams on Green Diamond's ownership in the HPAs: eight in in 1994 and eight additional streams in 1995. Information regarding the distribution of LWD was also obtained in the channel and habitat typing assessment process, but the importance of LWD to biological and physical processes in the stream channel justified the need for a more thorough assessment of this critical habitat component. The LWD surveys covered two distinct zones:

- LWD within the bankfull discharge area of the stream channel; and
- LWD and live trees within the "recruitment zone," defined as the area encompassing the floodplain and 50 feet of the hillslope beyond the bankfull channel margin.

The objectives of the LWD survey include:

- Accurately documenting the current abundance, distribution, and characteristics of instream LWD.
- Providing a repeatable methodology for monitoring long-term changes in the abundance, distribution, and characteristics of instream LWD.
- Accurately identifying the source of instream LWD (naturally recruited or restoration structure) and the species composition of instream LWD (hardwood or conifer).

The LWD survey was conducted using the CDFG methods (Flosi and Reynolds, 1994). This methodology is a 20% sample that was designed with the objective of quickly identifying stream reaches lacking in LWD for prioritizing restoration projects. Each stream reach is delineated by Rosgen Channel Type during the CDFG Habitat Typing process. During these LWD surveys 200' out of every 1000' of each channel type would be inventoried for both inchannel LWD and recruitment zone LWD.

Little River and three of its primary tributaries were inventoried for LWD in 1994 by Louisiana Pacific (LP) Fisheries Biologists. In 1998 Green Diamond Timber acquired the LP timberlands as well as their historical fisheries data for Little River. LP's LWD survey was a 100% inventory that tallied all inchannel pieces of LWD within the Bankfull

margins. In LP's survey no riparian or recruitment zone inventory was conducted and the inchannel inventory grouped the 3' – 4' category with the >4' category. This lack of information is noted in the following tables that summarize the Little River LWD data.

C2.1.2 Index of LWD Volume

An index of volume was developed for the purposes of depicting and comparing the amount of LWD in each stream to the watershed area. At the time of the survey/inventory, LWD pieces were categorized as follows based on their length: 6-20 feet, and >20 feet. In addition the LWD pieces were categorized as follows based on their maximum diameter: 1-2 feet, 2-3 feet, 3-4 feet, and >4 feet. The volume index was calculated by multiplying the mean diameter class times the "mean" length class. The mean diameter classes used for calculating the volume index were: 1.5 feet for the 1-2' class, 2.5 feet for the 2-3', 3.5 feet for the 3-4' class, and 4 feet for the >4' class. The "mean" lengths used for calculating the volume index were: 13 feet for the 6- 20' class and 20 feet for the >20' class. The index of volume was based on the instream average pieces per 100 feet. Since the actual diameters and lengths were not measured for each piece, the calculated volume in not a "true" volume but rather an index of volume. The index allows comparison between streams on Green Diamond property within the different HPAs.

C2.1.3 100% In-Channel Inventory

During Green Diamond's 1994 surveys field crews noted that a 20% sample could significantly underestimate or overestimate the actual pieces per 100 feet of channel. For example within a short channel type, where only 400 or 600 feet of channel were sampled, it is possible that one large log jam could skew the survey results to indicate that there are more pieces per 100 feet than actually exist in the reach. Conversely, if in that same short reach of channel the survey locations randomly missed most of the LWD, the results would be artificially low. To test these possibilities, an additional 100% inventory was conducted on all of the streams surveyed in 1995. The 100% inventory and the CDFG 20% sample were conducted simultaneously. This data allows a direct comparison of the CDFG methodology to a known inventory and thus is an indicator of the accuracy of a 20% sample.

C2.1.4 1999 Prairie Creek Inventory by Redwood National Park

In-channel and recruitment zone LWD data from undisturbed watersheds in coastal California are needed to compare with data from managed forests in the same area. This need led to the cooperative effort with Redwood National Park (RNP) and National Marine Fisheries Service (NMFS) to inventory inchannel LWD in Prairie Creek. In 1999 RNP and NMFS conducted a 100% inventory of 4.3 miles of Prairie Creek in Prairie Creek National Park. Prairie Creek is considered to be the best remaining example of a watershed dominated by old growth redwood forest. While this survey focused on quantifying LWD volume rather than a piece count per unit length, the data has been summarized by size categories of inchannel pieces (Kramer, pers. Comm.). This data should be considered as a known or true piece count of a relatively undisturbed watershed that may be directly compared to both the CDFG 20% samples and the 100% inventories conducted in Plan Area streams. However, when comparing Prairie Creek and many of the assessed Plan Area streams, the differences in their channel morphology must be considered. Prairie Creek is a low–gradient alluvial channel in a

relatively wide valley bottom, while many of the Plan Area streams are higher gradient in more incised channels.

C2.2 RESULTS

C2.2.1 LWD Sampling Survey Results

Results of Green Diamond's 1994 and 1995 LWD surveys and the 1994 Louisiana Pacific LWD inventories are summarized in Tables C2-1 through C2-14. Tables C2-1 through C2-7 contains the estimated overall LWD piece count, displayed as average pieces per 100 feet of channel, delineated by Rosgen Channel Type, condition (dead vs. live), and live species. Figure C2-1 depicts each stream's mean count of instream LWD per 100 feet of stream channel plotted against the stream's watershed area. Figure C2-2 graphically depicts, for each stream surveyed, the mean number of LWD pieces in the riparian recruitment zone per 100 feet of stream channel. Tables C2-8 through C2-14) provides summaries of the LWD data delineated by size categories both in the channel and in the riparian recruitment zone. In Figure C2-3, the index of LWD volume for each stream surveyed is plotted against that stream's watershed area.

In the 20 streams surveyed, the average amount of inchannel LWD ranged from zero pieces per 100 linear feet of an A2 channel type in North Fork Mad River (North Fork Mad River HPA) to 16.3 pieces per 100 linear feet of an F3 channel in Salmon Creek (Humboldt Bay HPA). The average amount of live conifers in the recruitment zone (50 feet beyond the bankfull channel) that could potentially become instream LWD ranged from 0 pieces per 100 linear feet in three sections of Long Prairie Creek (Mad River HPA) to 9.5 pieces per 100 linear feet of channel in the upper reaches of Salmon Creek (Humboldt Bay HPA). The survey also divided LWD pieces into eight size classes by length (greater or less than 20') and by diameter (1'-2', 2'-3', 3'-4', and over 4') to identify dominant size classes of LWD. Of the twenty streams surveyed in 1994 and 1995, the dominant, or co-dominant size class of inchannel LWD for all streams was 1'-2' diameter and less than 20' in length. The dominant size class in the riparian zone for all sixteen streams with Recruitment Zone surveys was consistently 1'-2' diameter and greater than 20' in length. The summarized results of the LWD surveys are presented in the tables below.

As shown in Figure C2-1, the mean number of instream LWD pieces per 100 feet of stream channel decreased significantly with increased watershed area. While there is some variability the trend for streams with less than approximately 4,000 acres in the watershed, the number of instream pieces of LWD is generally greater than 3 per 100 feet of channel (Figure C2-1). For streams with watershed areas greater than approximately 4,000 acres, the mean number of instream pieces of LWD is generally less than 3 pieces per 100 feet of stream channel (Figure C2-1).

The number of pieces of LWD within the stream recruitment zone for each of the Streams surveyed is shown in Figure C2-2. As shown in Figure C2-2, the mean number of pieces of LWD per 100 feet of channel in the riparian recruitment zone ranged from approximately 3.5 in Wilson Creek (Smith River HPA) to 12.5 for the South Fork Ah Pah Creek (Coastal Klamath River HPA). Streams within in the Coastal Klamath and Blue Creek HPAs had 5 of the 7 greatest mean number of LWD pieces (7.7 to 12.6 pieces) in the recruitment zone per 100 feet of stream channel of all streams surveyed.

Table C2-1. Summary of 1994 and 1995 LWD sample (average pieces per 100 feet by channel type), Smith River HPA.

South Fork Winchuck River		Recruitment Zone					In Channel	
Reach	**Channel Type**	**Dead & Down**	**Dead & Standing**	**Perched**	**Live Conifer**	**Live Deciduous**	**LWD**	**No. of Sections**
1	C4	0.5	0.1	0.1	0.2	7.1	1.2	16
2	F4	0.2	0.3	0.0	0.5	7.8	0.3	3
3	C4	1.3	0.1	0.0	0.9	5.9	2.4	7
4	D3	0.5	0.0	0.0	0.5	3.5	0.0	1
5	A2	1.5	1.0	0.5	0.5	6.4	3.0	4
Rowdy Creek		**Recruitment Zone**					**In Channel**	
Reach	**Channel Type**	**Dead & Down**	**Dead & Standing**	**Perched**	**Live Conifer**	**Live Deciduous**	**LWD**	**No. of Sections**
1	D4	0.3	0.0	0.0	0.3	1.1	0.7	12
2	B3	0.4	0.4	0.2	0.5	3.6	1.4	16
3	B2	0.2	0.5	0.3	0.7	5.5	0.5	6
4	F3	0.8	0.3	0.0	1.5	8.5	0.2	3
Dominie Creek		**Recruitment Zone**					**In Channel**	
Reach	**Channel Type**	**Dead & Down**	**Dead & Standing**	**Perched**	**Live Conifer**	**Live Deciduous**	**LWD**	**No. of Sections**
1	F3	1.0	0.4	0.1	0.6	3.2	1.8	8
2	A3	0.8	0.2	0.0	1.7	6.2	3.3	3
3	F3	3.0	1.0	0.0	3.5	2.0	1.0	1
4	A2	0.9	0.5	1.0	2.1	2.9	6.9	4
Wilson Creek		**Recruitment Zone**					**In Channel**	
Reach	**Channel Type**	**Dead & Down**	**Dead & Standing**	**Perched**	**Live Conifer**	**Live Deciduous**	**LWD**	**No. of Sections**
1	F4	1.7	0.2	0.1	1.2	4.1	2.0	35
2	B3	2.5	2.0	0.2	1.8	2.2	2.7	3

Table C2-2. Summary of 1994 and 1995 LWD sample (average pieces per 100 feet by channel type), Coastal Klamath HPA.

Hunter Creek		Recruitment Zone					In-Channel	
Reach	Channel Type	Dead & Down	Dead & Standing	Perched	Live Conifer	Live Deciduous	LWD	No. of Sections
1	F4	0.5	0.0	0.0	0.3	8.2	0.4	8
2	D4	0.6	0.1	0.1	0.5	2.9	1.8	25
3	B4	1.2	0.2	0.0	1.5	4.7	3.4	11
4	F3	2.2	0.5	0.0	1.2	4.7	3.7	3
5	F4	3.8	0.7	0.4	1.4	2.9	5.2	9
Terwer Creek		**Recruitment Zone**					**In Channel**	
Reach	Channel Type	Dead & Down	Dead & Standing	Perched	Live Conifer	Live Deciduous	LWD	No. of Sections
1	F4	1.6	0.2	0.1	1.5	2.0	3.6	18
2	F3	2.1	1.5	0.2	2.7	5.3	3.5	13
3	F2	4.1	1.9	0.1	3.8	6.4	1.5	15
4	F4	3.3	3.9	0.2	2.6	0.8	3.3	16
North Fork Ah Pah Creek		**Recruitment Zone**					**In Channel**	
Reach	Channel Type	Dead & Down	Dead & Standing	Perched	Live Conifer	Live Deciduous	LWD	No. of Sections
1	F4	0.2	0.3	0.0	3.2	2.1	1.7	5
2	A2	5.0	1.5	0.0	2.0	7.5	6.5	1
3	B3	3.6	1.1	0.0	3.4	7.1	5.8	4
4	B2	4.8	1.8	0.0	5.8	8.5	4.5	2
5	A2	5.2	0.8	0.2	4.7	7.0	4.7	3
6	F4	2.4	1.8	0.2	4.8	6.4	5.8	13
South Fork Ah Pah Creek		**Recruitment Zone**					**In Channel**	
Reach	Channel Type	Dead & Down	Dead & Standing	Perched	Live Conifer	Live Deciduous	LWD	No. of Sections
1	B4	4.8	0.1	0.1	1.1	2.6	2.1	5
2	A3	5.8	0.2	0.4	3.0	2.8	7.9	5
Ah Pah Creek		**Recruitment Zone**					**In Channel**	
Reach	Channel Type	Dead & Down	Dead & Standing	Perched	Live Conifer	Live Deciduous	LWD	No. of Sections
1	C4	0.8	0.2	0.7	2.7	2.5	2.1	6
2	D4	3.5	1.2	0.0	2.3	2.7	3.3	3
3	F3	3.5	1.3	0.0	5.3	1.3	2.3	2
4	A2	8.0	0.0	0.0	1.5	0.5	6.0	1
5	F4	6.6	0.3	0.0	3.3	1.4	7.0	4
6	A2	7.0	0.5	0.0	2.5	5.5	7.0	1
7	F3	4.4	1.0	0.4	2.6	4.6	5.8	4

Table C2-3. Summary of 1994 and 1995 LWD sample (average pieces per 100 feet by channel type), Blue Creek HPA.

West Fork Blue Creek		Recruitment Zone					In Channel	
Reach	Channel Type	Dead & Down	Dead & Standing	Perched	Live Conifer	Live Deciduous	LWD	No. of Sections
1	B2	0.8	0.2	0.0	1.5	3.5	1.8	5
2	A2	3.7	0.7	0.1	2.6	2.8	3.2	18

Table C2-4. Summary of 1994 and 1995 LWD sample (average pieces per 100 feet by channel type), Little River HPA.

Little River		Recruitment Zone (N/A)					In Channel	
Reach	Channel Type	Dead & Down	Dead & Standing	Perched	Live Conifer	Live Deciduous	LWD	Length of Survey (ft)
1	B3	N/A	N/A	N/A	N/A	N/A	2.2	1614
2	B2	N/A	N/A	N/A	N/A	N/A	1.5	5506
3	B3	N/A	N/A	N/A	N/A	N/A	2.8	3526
4	F2	N/A	N/A	N/A	N/A	N/A	3.2	3214
5	F3	N/A	N/A	N/A	N/A	N/A	1.4	1366
6	B2	N/A	N/A	N/A	N/A	N/A	2.0	10902
7	B4	N/A	N/A	N/A	N/A	N/A	2.5	9876
8	B2	N/A	N/A	N/A	N/A	N/A	2.4	6347
9	A2	N/A	N/A	N/A	N/A	N/A	3.2	1062
10	B2	N/A	N/A	N/A	N/A	N/A	4.2	9415
11	B3	N/A	N/A	N/A	N/A	N/A	5.1	2412
12	B2	N/A	N/A	N/A	N/A	N/A	8.8	2644
13	B4	N/A	N/A	N/A	N/A	N/A	10.2	3339
14	A2	N/A	N/A	N/A	N/A	N/A	9.8	1546
Railroad Cr.		**Recruitment Zone**					**In Channel**	
Reach	**Channel Type**	**Dead & Down**	**Dead & Standing**	**Perched**	**Live Conifer**	**Live Deciduous**	**LWD**	**Length of Survey (ft)**
1	F4	N/A	N/A	N/A	N/A	N/A	4.1	748
2	B2	N/A	N/A	N/A	N/A	N/A	6.7	3901
3	B3	N/A	N/A	N/A	N/A	N/A	7.8	1998
4	B4	N/A	N/A	N/A	N/A	N/A	13.1	1244
Lower South Fork Little River		**Recruitment Zone**					**In Channel**	
Reach	**Channel Type**	**Dead & Down**	**Dead & Standing**	**Perched**	**Live Conifer**	**Live Deciduous**	**LWD**	**Length of Survey (ft)**
1	F4	N/A	N/A	N/A	N/A	N/A	5.9	7594
2	F3	N/A	N/A	N/A	N/A	N/A	8.4	2042
3	B2	N/A	N/A	N/A	N/A	N/A	9.3	961
4	C4	N/A	N/A	N/A	N/A	N/A	9.4	1679
5	F3	N/A	N/A	N/A	N/A	N/A	10.9	1628
Upper South Fork Little River		**Recruitment Zone**					**In Channel**	
Reach	**Channel Type**	**Dead & Down**	**Dead & Standing**	**Perched**	**Live Conifer**	**Live Deciduous**	**LWD**	**Length of Survey (ft)**
1	B3	N/A	N/A	N/A	N/A	N/A	4.4	2437
2	B2	N/A	N/A	N/A	N/A	N/A	3.4	1250
3	A2	N/A	N/A	N/A	N/A	N/A	6.3	2190
4	F3	N/A	N/A	N/A	N/A	N/A	6.0	3942
5	B4	N/A	N/A	N/A	N/A	N/A	14.8	583

Table C2-5. Summary of 1994 and 1995 LWD sample (average pieces per 100 feet by channel type), Mad River HPA.

Lindsay Creek		Recruitment Zone					In Channel	
Reach	Channel Type	Dead & Down	Dead & Standing	Perched	Live Conifer	Live Deciduous	LWD	No. of Sections
1	F5	0.9	0.5	0.1	4.9	2.9	3.6	28
Cañon Creek		**Recruitment Zone**					**In Channel**	
Reach	**Channel Type**	**Dead & Down**	**Dead & Standing**	**Perched**	**Live Conifer**	**Live Deciduous**	**LWD**	**No. of Sections**
1	B4	0.5	1.0	0.5	5.8	2.3	1.3	2
2	D4	0.5	0.3	0.8	4.1	2.6	4.9	4
3	B3	2.6	0.5	0.4	5.0	3.5	1.5	4
4	F3	1.1	0.3	0.0	6.4	2.1	0.3	8
5	A2	1.3	0.1	0.4	6.6	3.4	1.8	6
Dry Creek		**Recruitment Zone**					**In Channel**	
Reach	**Channel Type**	**Dead & Down**	**Dead & Standing**	**Perched**	**Live Conifer**	**Live Deciduous**	**LWD**	**No. of Sections**
1	B4	0.9	1.1	0.3	2.8	1.8	1.8	4
2	A3	2.0	0.5	0.0	1.5	3.5	0.5	1
3	B3	0.0	1.0	1.0	2.5	10.0	6.5	1

Table C2-6. Summary of 1994 and 1995 LWD sample (average pieces per 100 feet by channel type), North Fork Mad River HPA.

North Fork Mad River		Recruitment Zone					In Channel	
Reach	Channel Type	Dead & Down	Dead & Standing	Perched	Live Conifer	Live Deciduous	LWD	No. of Sections
1	F4	0.2	0.0	0.1	1.1	0.8	0.6	12
2	B3	1.3	0.1	0.1	4.0	1.1	0.4	4
3	F2	0.3	0.1	0.3	3.2	0.8	0.2	6
4	A2	1.8	0.0	0.1	1.0	2.5	0.0	4
5	F2	1.4	0.4	0.3	6.2	4.7	1.1	36
6	F4	1.7	1.2	0.1	7.7	3.1	1.7	6
7	F3	1.4	1.0	0.1	6.6	2.6	1.4	7
8	F4	1.3	0.4	0.2	5.7	2.9	2.2	9
Long Prairie Creek		**Recruitment Zone**					**In Channel**	
Reach	**Channel Type**	**Dead & Down**	**Dead & Standing**	**Perched**	**Live Conifer**	**Live Deciduous**	**LWD**	**No. of Sections**
1	B3	1.9	2.5	0.4	2.6	9.7	2.4	7
2	B2	3.0	0.0	1.5	0.5	5.5	1.5	1
3	B3	2.0	1.2	0.3	5.8	6.3	5.3	3
4	F3	1.3	0.0	0.0	0.0	11.8	0.0	2
5	B2	3.5	0.0	1.5	0.0	6.0	3.5	1
6	F3	2.0	0.0	1.0	4.3	3.5	0.5	2
7	B2	6.5	0.5	0.0	0.0	4.0	0.0	1

Table C2-7. Summary of 1994 and 1995 LWD sample (average pieces per 100 feet by channel type), Humboldt Bay HPA.

Salmon Creek		Recruitment Zone					In Channel	
Reach	Channel Type	Dead & Down	Dead & Standing	Perched	Live Conifer	Live Deciduous	LWD	No. of Sections
1	F3	1.3	0.3	0.4	1.9	1.8	1.8	19
2	F1	0.8	0.5	0.5	3.8	1.8	3.0	2
3	F3	4.5	0.3	0.3	5.5	0.8	16.3	2
4	F1	0.0	0.0	0.0	1.0	0.0	5.0	1
5	F3	1.9	0.3	0.3	5.7	2.3	4.5	8
6	B2	3.3	0.7	1.2	9.5	6.4	6.1	7

Table C2-8. Summary of 1994 and 1995 LWD sample (average pieces per 100 feet by channel type), Smith River HPA.

Stream	Size Classes of In-channel LWD and Wood within Riparian Recruitment Zone								
	1'-2' max dia.[a]; <20'	1'-2' max dia.[a]; >20'	2'-3' max dia.[a]; <20'	2'-3' max dia.[a]; >20'	3'-4' max dia.[a]; <20'	3'-4' max dia.[a]; >20'	>4' max dia.[a]; <20'	>4' max dia.[a]; >20'	All Size Classes
SF WINCHUCK									
Instream LWD	0.8	0.4	0.2	0.1	0.1	0.0	0.1	0.0	1.7
Riparian	0.2	4.2	0.1	0.7	0.1	0.2	0.0	0.1	5.6
Total	1.0	4.6	0.3	0.8	0.2	0.2	0.1	0.1	7.3
ROWDY CREEK									
Instream LWD	0.2	0.2	0.1	0.0	0.2	0.1	0.1	0.0	0.9
Riparian	0.3	2.1	0.0	0.8	0.0	0.2	0.0	0.1	3.5
Total	0.5	2.3	0.1	0.8	0.2	0.3	0.1	0.1	4.4
DOMINIE CREEK									
Instream LWD	1.7	0.3	0.5	0.4	0.2	0.2	0.1	0.0	3.4
Riparian	0.5	3.8	0.2	1.3	0.1	0.4	0.0	0.1	6.4
Total	2.2	4.1	0.7	1.7	0.3	0.6	0.1	0.1	9.8
WILSON CREEK									
Instream LWD	0.4	0.4	0.4	0.3	0.1	0.1	0.2	0.2	2.1
Riparian	0.4	2.8	0.4	0.9	0.1	0.2	0.3	0.2	5.3
Total	0.8	3.2	0.8	1.2	0.2	0.3	0.5	0.4	7.4

[a] = maximum diameter of LWD piece

Table C2-9. Summary of 1994 and 1995 LWD sample (average pieces per 100 feet by channel type), Coastal Klamath HPA.

Stream	Size Classes of Inchannel LWD and Wood within Riparian Recruitment Zone								
	1'-2' max dia.[a]; <20'	1'-2' max dia.[a]; >20'	2'-3' max dia.[a]; <20'	2'-3' max dia.[a]; >20'	3'-4' max dia.[a]; <20'	3'-4' max dia.[a]; >20'	>4' max dia.[a]; <20'	>4' max dia.[a]; >20'	All Size Classes
HUNTER CREEK									
Instream LWD	0.8	0.4	0.3	0.3	0.2	0.2	0.3	0.2	2.7
Riparian	0.3	3.1	0.3	0.6	0.1	0.3	0.2	0.2	5.1
Total	1.1	3.5	0.6	0.9	0.3	0.5	0.5	0.4	7.8
TERWER									
Instream LWD	0.7	0.6	0.3	0.4	0.2	0.3	0.2	0.4	3.1
Riparian	0.6	4.5	0.3	1.1	0.1	0.5	0.2	0.4	7.7
Total	1.3	5.1	0.6	1.5	0.3	0.8	0.4	0.8	10.8
AH PAH									
Instream LWD	2.0	0.7	0.8	0.3	0.3	0.1	0.2	0.2	4.6
Riparian	1.3	4.1	0.5	1.2	0.5	0.4	0.6	0.4	9.0
Total	3.3	4.8	1.3	1.5	0.8	0.5	0.8	0.6	13.6
NORTH FORK AH PAH									
Instream LWD	2.1	0.7	1.0	0.2	0.2	0.1	0.5	0.2	5.0
Riparian	0.7	6.9	0.6	1.0	0.3	0.4	0.8	0.6	11.3
Total	2.8	7.6	1.6	1.2	0.5	0.5	1.3	0.8	16.3
SOUTH FORK AH PAH									
Instream LWD	2.6	0.3	1.0	0.5	0.3	0.3	0.3	0.3	5.6
Riparian	1.2	6.1	1.1	1.6	0.6	0.6	0.7	0.8	12.7
Total	3.8	6.4	2.1	2.1	0.9	0.9	1.0	1.1	18.3

Table C2-10. Summary of 1994 and 1995 LWD sample (average pieces per 100 feet by channel type), Blue Creek HPA.

Stream	Size Classes of Inchannel LWD and Wood within Riparian Recruitment Zone								
	1'-2' max dia.[a]; <20'	1'-2' max dia.[a]; >20'	2'-3' max dia.[a]; <20'	2'-3' max dia.[a]; >20'	3'-4' max dia.[a]; <20'	3'-4' max dia.[a]; >20'	>4' max dia.[a]; <20'	>4' max dia.[a]; >20'	All Size Classes
WEST FORK BLUE CREEK									
Instream LWD	1.4	0.9	0.4	0.1	0.2	0.1	0.1	0.0	3.2
Riparian	1.7	4.6	0.5	0.8	0.1	0.1	0.0	0.0	7.8
Total	3.1	5.5	0.9	0.9	0.3	0.2	0.1	0.0	11.0

Table C2-11. Summary of 1994 and 1995 LWD sample (average pieces per 100 feet by channel type), Little River HPA.

Stream	Size Classes of In-channel LWD and Wood within Riparian Recruitment Zone						
	1'-2' max dia.[a]; <20'	1'-2' max dia.[a]; >20'	2'-3' max dia.[a]; <20'	2'-3' max dia.[a]; >20'	>3' max dia.[a]; <20'	>3' max dia.[a]; >20'	All Size Classes
LITTLE RIVER							
Instream LWD	1.2	0.9	0.5	0.4	0.3	0.2	3.5
RAILROAD							
Instream LWD	3.0	1.4	1.9	1.0	0.4	0.3	8.0
LOWER SOUTH FORK LITTLE RIVER							
Instream LWD	3.6	1.2	1.6	0.7	0.5	0.4	8.0
UPPER SOUTH FORK LITTLE RIVER							
Instream LWD	2.8	0.8	1.2	0.4	0.5	0.2	5.9

[a] = maximum diameter of LWD piece

Table C2-12. Summary of 1994 and 1995 LWD sample (average pieces per 100 feet by channel type), North Fork Mad River HPA.

Stream	Size Classes of Inchannel LWD and Wood within Riparian Recruitment Zone								
	1'-2' max dia.[a]; <20'	1'-2' max dia.[a]; >20'	2'-3' max dia.[a]; <20'	2'-3' max dia.[a]; >20'	3'-4' max dia.[a]; <20'	3'-4' max dia.[a]; >20'	>4' max dia.[a]; <20'	>4' max dia.[a]; >20'	All Size Classes
NF MAD RIVER									
Instream LWD	0.2	0.3	0.1	0.1	0.1	0.0	0.2	0.0	1.0
Riparian	0.2	4.1	0.1	1.2	0.1	0.3	0.2	0.1	6.3
Total	0.4	4.4	0.2	1.3	0.2	0.3	0.4	0.1	7.3
LONG PRAIRIE CREEK									
Instream LWD	1.0	0.5	0.1	0.4	0.0	0.2	0.0	0.0	2.2
Riparian	1.5	6.2	0.1	1.5	0.0	0.5	0.0	0.1	9.9
Total	2.5	6.7	0.2	1.9	0.0	0.7	0.0	0.1	12.1

[a] = maximum diameter of LWD piece

Table C2-13. Summary of 1994 and 1995 LWD sample (average pieces per 100 feet by channel type), Mad River HPA.

Stream	Size Classes of Inchannel LWD and Wood within Riparian Recruitment Zone								
	1'-2' max dia.[a]; <20'	1'-2' max dia.[a]; >20'	2'-3' max dia.[a]; <20'	2'-3' max dia.[a]; >20'	3'-4' max dia.[a]; <20'	3'-4' max dia.[a]; >20'	>4' max dia.[a]; <20'	>4' max dia.[a]; >20'	All Size Classes
LINDSAY									
Instream LWD	1.9	0.3	0.6	0.2	0.3	0.1	0.2	0.1	3.7
Riparian	0.4	4.1	0.1	1.6	0.1	0.6	0.2	0.6	7.7
Total	2.3	4.4	0.7	1.8	0.4	0.7	0.4	0.7	11.4
DRY CREEK									
Instream LWD	0.9	0.1	0.3	0.1	0.0	0.0	0.0	0.0	1.4
Riparian	0.6	3.2	0.1	1.1	0.2	0.2	0.7	0.1	6.2
Total	1.5	3.3	0.4	1.2	0.2	0.2	0.7	0.1	7.6
CAÑON CR.									
Instream LWD	0.6	0.6	0.2	0.1	0.1	0.0	0.2	0.0	1.8
Riparian	0.9	3.8	0.1	1.7	0.2	0.3	0.1	0.1	7.2
Total	1.5	4.4	0.3	1.8	0.3	0.3	0.3	0.1	9.0

[a] = maximum diameter of LWD piece

Table C2-14. Summary of 1994 and 1995 LWD sample (average pieces per 100 feet by channel type), Humboldt Bay HPA.

Stream	Size Classes of Inchannel LWD and Wood within Riparian Recruitment Zone								
	1'-2' max dia.[a]; <20'	1'-2' max dia.[a]; >20'	2'-3' max dia.[a]; <20'	2'-3' max dia.[a]; >20'	3'-4' max dia.[a]; <20'	3'-4' max dia.[a]; >20'	>4' max dia.[a]; <20'	>4' max dia.[a]; >20'	All Size Classes
SALMON CREEK									
Instream LWD	0.8	0.8	0.5	0.3	0.4	0.4	0.4	0.4	4.0
Riparian	0.5	4.1	0.3	1.0	0.2	0.4	0.4	0.2	7.1
Total	1.3	4.9	0.8	1.3	0.6	0.8	0.8	0.6	11.1

[a] = maximum diameter of LWD piece

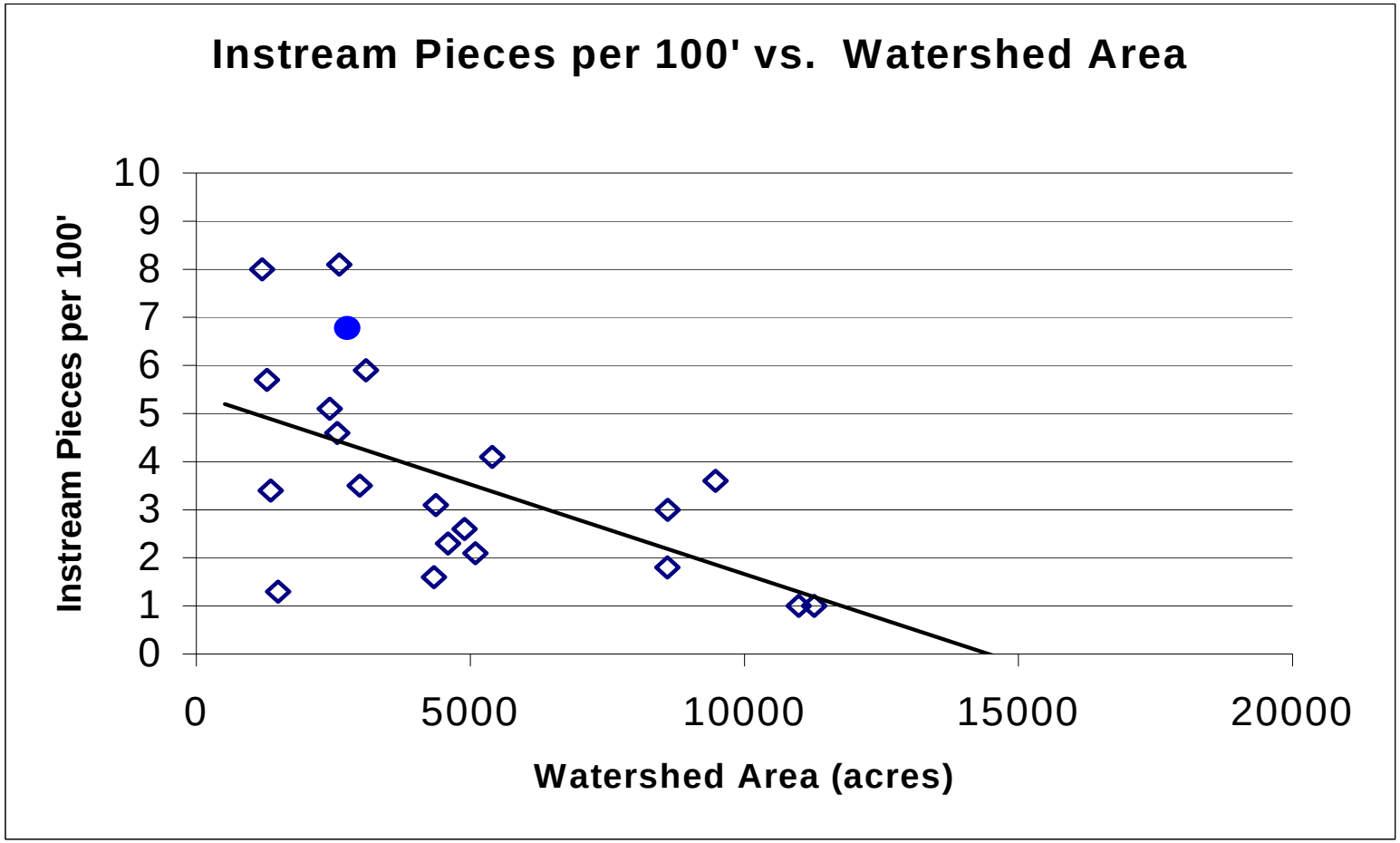

Figure C2-1. Summary of mean number of instream LWD pieces per 100 feet of stream channel versus stream watershed area for 20 Plan Area streams. (Note: solid circle depicts Prairie Creek for reference.)

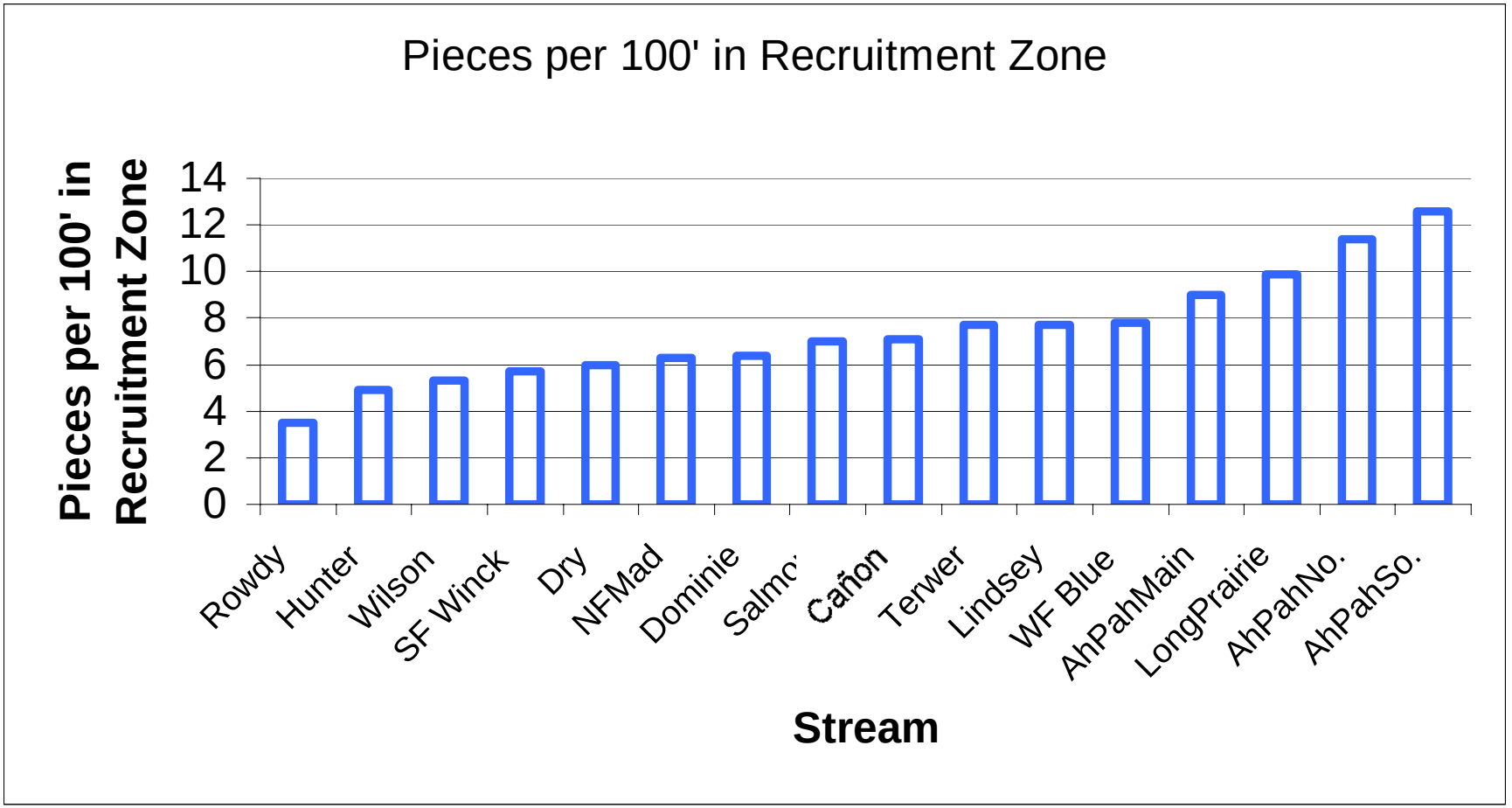

Figure C2-2. Summary of the mean number of LWD pieces in the recruitment zone per 100 feet of stream channel for 16 Plan Area streams.

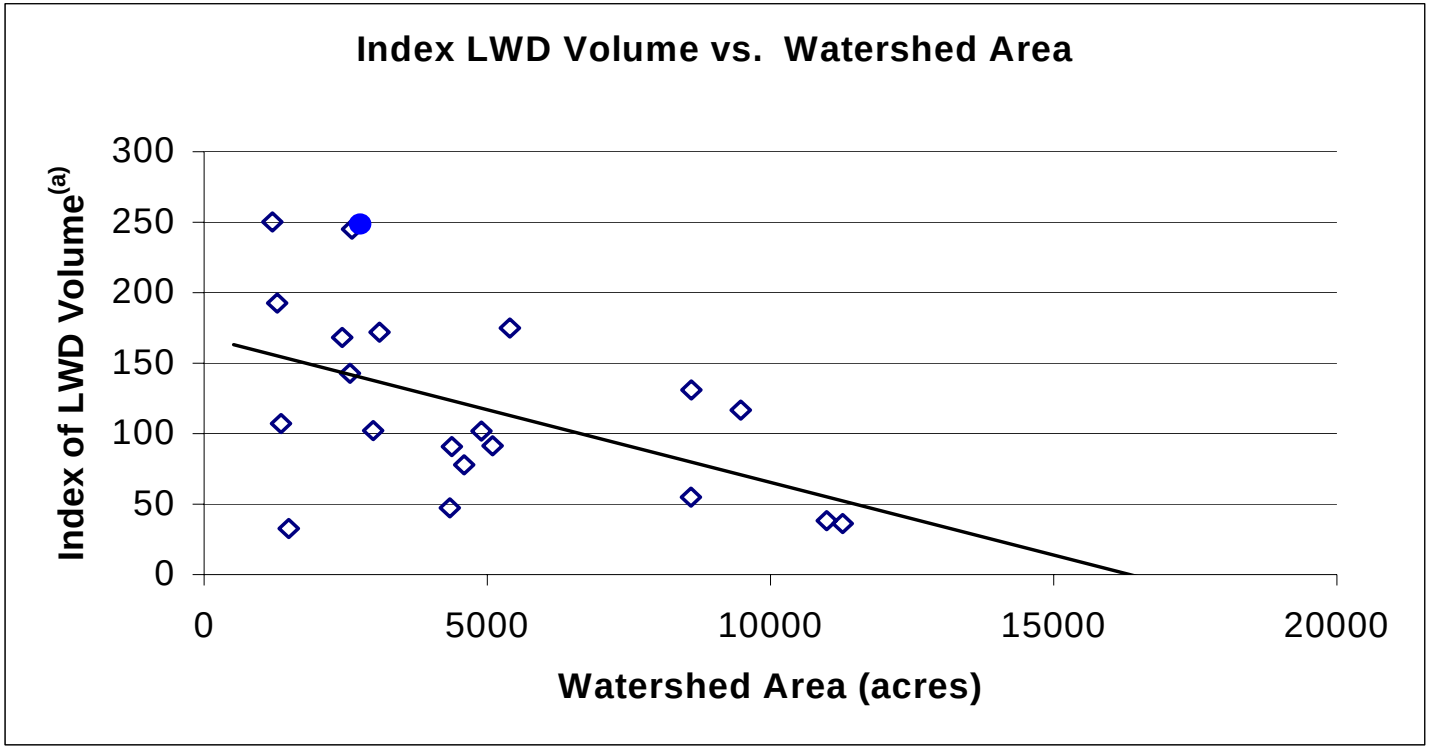

Figure C2-3. LWD volume index versus watershed area for 20 Plan Area streams (Note: solid circle represents Prairie Creek for reference). (Index equals the maximum diameter times the mid-point of the LWD length class.)

The results of the LWD surveys indicate that most streams surveyed had low amounts of inchannel LWD that consisted of the smallest size categories. Eleven of the sixteen streams with riparian surveys had low amounts of conifer abundance (relative to hardwoods) within the recruitment zone. These results support the conclusions drawn from the channel and habitat typing assessment: there are generally low levels of inchannel LWD available to function as shelter or to promote formation of pools in the surveyed streams. The dominant size class of inchannel LWD also parallels channel assessment descriptions of smaller diameter, alder dominated riparian zones with low numbers of large conifer (greater than 3' in diameter) as potential LWD.

As shown in Figure C2-3, an index of LWD volume for each stream surveyed was calculated and plotted against each stream's watershed area. Similar to the trend shown in Figure C2-1, (fewer pieces per 100 feet of channel with larger watershed areas) volume of LWD generally decreased with increases in watershed area (Figure C2-3).

C2.2.2 LWD Inventory Results

Results of Green Diamond's 1995 Inchannel LWD inventory are summarized in Tables C2-15 through C2-17. These tables summarize the 100% inchannel inventory displaying average pieces per 100 feet by Rosgen Channel Type and piece size category. The last two lines for each stream are the weighted average pieces per 100 feet of channel as determined by both the inventory and the 20% sample.

The results of the 1995 100% Inchannel LWD Inventory suggest that the 20% sample is comparable. CDFG's 20% sample is adequate for an estimate of average pieces per linear distance but does not address any volume or function related issues. The overall goal of the survey as designed by CDFG was to identify specific stream reaches that are in need of restoration in the form of additional LWD. To address the issues of total volume or inchannel function more detailed surveys will be needed.

C2.2.3 Prairie Creek LWD Inventory Results

The Prairie Creek inventory data is displayed in Table C2-18 as average pieces per 100 feet of channel in the various size categories. For a graphic comparison of the LWD data for Prairie Creek and the surveyed Plan Area streams, see Figures C2-1 and C2-3 above.

The section of Prairie Creek that was inventoried is a low gradient, small cobble dominated channel (Rosgen Channel Type of C4) that is considered to be a relatively undisturbed reach. Results of the Prairie Creek LWD data revealed that inchannel LWD occurred at an average of 6.8 pieces per 100 linear feet of channel for the 4.3 miles of channel inventoried (Kramer, pers. comm.)(Figure C2-1). This value exceeds all but two of the ranges calculated for any single average for the surveyed Plan Area streams (1.0 - 8.1 pieces/100'). Two tributaries in the Little River HPA, Lower South Fork and Railroad, had average piece counts at 8.1 and 8.0 pieces/100' respectively.

Table C2-15. Summary of 1995 100% in-channel LWD inventory (average pieces per 100 feet by channel type and size category), Smith River HPA.

Stream	Size Classes of In-channel LWD								
	1'-2' max dia.[a]; <20'	1'-2' max dia.[a]; >20'	2'-3' max dia.[a]; <20'	2'-3' max dia.[a]; >20'	3'-4' max dia.[a]; <20'	3'-4' max dia.[a]; >20'	>4' max dia.[a]; <20'	>4' max dia.[a]; >20'	All Size Classes
SOUTH FORK WINCHUCK RIVER									
C4	0.4	0.3	0.2	0.1	0.1	0.0	0.1	0.0	1.2
F4	0.7	0.8	0.2	0.1	0.0	0.0	0.1	0.0	1.9
C4	0.6	0.4	0.1	0.1	0.1	0.1	0.0	0.0	1.4
D3	2.3	0.4	0.0	0.0	0.2	0.2	0.0	0.0	3.2
A2	2.7	0.7	0.7	0.2	0.2	0.1	0.3	0.1	4.9
Weighted Average	0.8	0.4	0.2	0.1	0.1	0.0	0.1	0.0	1.7
20% sample	0.8	0.4	0.2	0.1	0.1	0.0	0.1	0.0	1.6
ROWDY CREEK									
D4	0.3	0.2	0.1	0.1	0.0	0.1	0.0	0.0	0.8
B3	0.1	0.1	0.1	0.0	0.0	0.0	0.1	0.0	0.4
B2	0.1	0.2	0.1	0.1	0.1	0.0	0.1	0.0	0.6
F3	0.9	0.4	0.2	0.2	0.0	0.1	0.1	0.0	2.0
Weighted Average	0.2	0.2	0.1	0.1	0.0	0.0	0.0	0.0	0.7
20% sample	0.2	0.2	0.1	0.0	0.2	0.1	0.1	0.0	0.9
DOMINIE CREEK									
F3	0.6	0.4	0.2	0.2	0.1	0.2	0.1	0.0	1.7
A3	2.6	1.0	1.3	0.7	0.4	0.5	0.1	0.1	6.6
F3	0.6	0.2	0.5	0.2	0.2	0.2	0.0	0.0	1.8
A2	2.6	0.4	0.9	0.3	0.4	0.2	0.2	0.1	5.0
Weighted Average	1.7	0.5	0.6	0.3	0.3	0.2	0.1	0.0	3.8
20% sample	1.7	0.3	0.5	0.4	0.2	0.2	0.1	0.0	3.4

[a] = maximum diameter of LWD piece

Table C2-16. Summary of 1995 100% in-channel LWD inventory (average pieces per 100 feet by channel type and size category), Coastal Klamath HPA.

Stream	Size Classes of Inchannel LWD								
	1'-2' max dia.[a]; <20'	1'-2' max dia.[a]; >20'	2'-3' max dia.[a]; <20'	2'-3' max dia.[a]; >20'	3'-4' max dia.[a]; <20'	3'-4' max dia.[a]; >20'	>4' max dia.[a]; <20'	>4' max dia.[a]; >20'	All Size Classes
AH PAH CREEK									
C4	1.7	0.7	0.4	0.2	0.1	0.1	0.2	0.1	3.4
D4	1.9	1.7	0.3	0.3	0.3	0.1	0.4	0.1	5.2
F3	2.4	0.3	0.5	0.3	0.1	0.1	0.1	0.1	4.0
A2	1.4	0.5	0.9	0.0	0.8	0.0	0.8	0.0	4.3
F4	2.5	0.3	1.3	0.0	0.6	0.1	0.3	0.1	5.2
A2	5.6	1.0	1.2	0.6	0.7	0.4	0.7	0.3	10.5
F3	3.1	0.3	1.4	0.3	0.9	0.1	0.7	0.1	6.9
Weighted Average	2.4	0.7	0.8	0.2	0.5	0.1	0.4	0.1	5.1
20% sample	2.0	0.7	0.8	0.3	0.3	0.1	0.2	0.2	4.6
NORTH FORK AH PAH CREEK									
F4	0.8	0.4	0.1	0.0	0.1	0.0	0.2	0.0	1.7
A2	3.7	0.6	0.7	0.2	0.2	0.1	0.3	0.1	5.9
B3	1.7	0.4	0.8	0.2	0.3	0.1	0.6	0.3	4.4
B2	1.5	0.9	1.3	0.1	0.2	0.1	0.4	0.3	4.9
A2	2.5	1.1	1.2	0.1	0.5	0.0	0.7	0.2	6.4
F4	2.0	0.5	0.8	0.1	0.3	0.1	0.5	0.1	4.4
Weighted Average	1.8	0.5	0.7	0.1	0.3	0.1	0.5	0.1	4.2
20% sample	2.1	0.7	1.0	0.2	0.2	0.1	0.5	0.2	5.1
SOUTH FORK AH PAH CREEK									
B4	1.2	0.6	0.5	0.3	0.1	0.2	0.2	0.1	3.1
A3	3.8	0.8	1.7	0.7	0.7	0.5	0.9	0.6	9.6
Weighted Average	2.4	0.7	1.0	0.5	0.3	0.3	0.5	0.3	6.1
20% sample	2.6	0.3	1.0	0.5	0.3	0.3	0.3	0.3	5.6

[a] = maximum diameter of LWD piece

Table C2-17. Summary of 1995 100% in-channel LWD inventory (average pieces per 100 feet by channel type and size category), Mad River HPA.

Stream	Size Classes of Inchannel LWD								
	1'-2' max dia.[a]; <20'	1'-2' max dia.[a]; >20'	2'-3' max dia.[a]; <20'	2'-3' max dia.[a]; >20'	3'-4' max dia.[a]; <20'	3'-4' max dia.[a]; >20'	>4' max dia.[a]; <20'	>4' max dia.[a]; >20'	All Size Classes
LINDSAY CREEK									
F5	1.8	0.4	0.5	0.2	0.2	0.1	0.1	0.1	3.4
20% sample	1.9	0.3	0.6	0.2	0.3	0.1	0.2	0.1	3.5
[a] = maximum diameter of LWD piece									

Table C2-18. Summary of 1999 100% in-channel LWD inventory (average pieces per 100 feet by size category), Prairie Creek.

Stream	Size Classes of Inchannel LWD								
	1'-2' max dia.[a]; <20'	1'-2' max dia.[a]; >20'	2'-3' max dia.[a]; <20'	2'-3' max dia.[a]; >20'	3'-4' max dia.[a]; <20'	3'-4' max dia.[a]; >20'	>4' max dia.[a]; <20'	>4' max dia.[a]; >20'	All Size Classes
PRAIRIE CREEK									
	2.8	1.1	0.8	0.7	0.3	0.4	0.2	0.6	6.8
[a] = maximum diameter of LWD piece									

Additionally, in five separate reaches within the Little River HPA and Salmon Creek, LWD tallies exceeded 6.8 pieces per 100 feet. When comparing the Prairie Creek results only to low gradient (<2%) stream reaches (Rosgen Channel Types C, D and F), five reaches in the surveyed Plan Area streams (three F3, one F4 and one C4 channel types) exceed the Prairie Creek values. These are Salmon Creek (16.3 pieces per 100') and Lower South Fork Little River (8.4, 9.4 and 10.9 pieces per 100') and Ah Pah Creek (7.0 pieces per 100'). In general, the surveyed Plan Area streams had, on average, more pieces per 100' in the higher gradient and more confined channel types. This intuitively makes sense; the smaller and steeper the stream the more likely it is for an individual LWD piece to be retained in the system.

In Prairie Creek the dominant category of inchannel LWD was in the 1' - 2' and less than 20' long" category (Table C2-18). This compares to the dominant, or co-dominant category of inchannel LWD for all but one of the surveyed Plan Area streams. The dominant inchannel category for the North Fork of the Mad River was the "1' to 2' and greater than 20' long". This difference can probably be attributed to the relatively larger size of the North Fork Mad River. In this stream an individual LWD piece less than 20 feet long would tend to be delivered through the system rather than be retained. The Prairie Creek results accurately reflect the LWD piece size for a relatively undisturbed coastal drainage. However, comparisons between Prairie Creek and many Plan Area streams may not be valid, because of differences in their morphology. Prairie Creek is a

low–gradient alluvial channel in a relatively wide valley bottom, while many Plan Area streams are higher gradient in more incised channels.

Numerous factors influence the frequency, size, distribution and function of LWD including: geographic location, dominant tree species, channel width, channel gradient and drainage area. As a result, comparing LWD inventories from Green Diamond's California timberlands with data from undisturbed watersheds in other states could be inappropriate or misleading. LWD inventories from additional undisturbed watersheds including an inland, Douglas fir dominated forest, and a coastal redwood forest with steeper channel gradients than those found in Lower Prairie Creek would aid in the analysis of the existing LWD results, as these conditions are common on Green Diamond timberlands. Inventories on undisturbed watersheds of varying drainage area and channel gradient would also aid in differentiating between the many factors that influence LWD distributions

C2.3 DISCUSSION

The LWD survey results reflect the effects of past timber management practices and early habitat improvement efforts. Throughout the surveyed Plan Area streams, there were generally low amounts of LWD; and the predominate size of the existing LWD was small (primarily 1'-2' diameter pieces). The lack of large pieces of LWD (> 4' diameter and > 20' long) suggests that surveyed stream channels have been subjected to extensive channel clearing as part of past timber harvesting practices and/or early habitat improvement efforts. The relative lack of large live trees (conifers with > 4' diameters) within the recruitment zone reflects the effects of pre-FPRs management practices that removed most merchantable conifers from riparian zones adjacent to stream channels and failed to re-establish conifers in these areas. As a result, most riparian zones in sampled watersheds tend to be dominated by alder, willow, and younger conifers.

Comparisons of logged and unlogged streams or reaches provide insights into management impacts on LWD loading, recruitment rate and downstream transport. Numerous studies have compared LWD in old growth, mature second growth and recently clear-cut watersheds in Alaska, British Columbia, Washington and Oregon (Sullivan et al. 1987; Bibly and Ward 1989, 1991; Murphy and Koski 1989; Ralph et al. 1994; McHenry et al. 1998). Some studies indicated that LWD frequency was reduced in managed watersheds (Bilby and Ward 1991, McHenry et. al. 1998) and others failed to prove or detect a difference in piece counts (Ralph et al. 1994). However, every study confirmed a statistically significant reduction in sizes of LWD pieces in managed watersheds, suggesting that size and volume of LWD pieces are more important than frequency of pieces in forming and maintaining complex habitat features.

The LWD structures placed by restoration groups are often undersized (mainly in length as opposed to maximum width) for several reasons, including: 1) monetary limits per structure as required by CDFG-administered restoration funds, 2) size constraints by the cull logs available at or near a work site or donated by timber companies, and/or 3) size constraints of cull logs that restoration groups can maneuver with their equipment. Most restoration projects have also failed to mimic natural conditions, tending to locate LWD structures along channel margins with minimal amounts of wood lying within the main channel, and rarely, if ever, fully spanning the channel with large conifer.

Comparing the results of the Prairie Creek inventory with the inventories for the surveyed Plan Area streams suggests that the occurrence of larger in-channel pieces is lower in managed streams within the Plan Area than in unmanaged streams nearby. Several of the surveyed Plan Area streams had average overall piece counts per 100' within specific size categories that approached or exceeded the values seen in Prairie Creek. However, the piece lengths in these managed streams were shorter than the piece lengths in Prairie Creek, especially in similar channel types. In the 20 surveyed Plan Area streams, most of the larger diameter LWD was either: 1) old-growth root wads with little or no bole attached to them, or 2) instream restoration projects consisting of short, stubby pieces of cull logs anchored to bedrock, boulders, or riparian trees. Both of these types of LWD often provide marginal habitat compared to intact trees recruited from the riparian zone. Old-growth redwood rootwads contain fairly large volumes of wood, yet their short length provides minimal surface area for capturing and retaining additional LWD to form complex salmonid habitat. The short length of these rootwads also increases their likelihood of mobilizing during moderate storm events (as occurred during the winters of 1995-96 and 1996-97).

C2.4 CONCLUSION

LWD within Plan Area streams will be reassessed periodically during the 50-year life of the Plan with the objective of documenting increases in conifer piece frequency, size, and functionality. Improvements in the current LWD inventories and sampling designs are needed to more accurately assess the changes in volume and function of LWD debris over longer periods of time. Conditions can be expected to gradually improve as a result of current FPRs and the increased riparian standards implemented under the Plan. The hardwood dominated riparian zones now prevalent on various Plan Area streams will eventually be succeeded by redwoods and other conifers, resulting in increasing recruitment of large diameter LWD for Plan Area streams. It has been suggested (McHenry et al. 1998, Emminghamm and Hibb 1996) that without active management of riparian zones; protection of existing conifers, conifer release and/or planting that conifer succession will be extremely slow or even effectively precluded.

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